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The Future of Science in America

An address delivered on Founder's Day
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By

CHARLES A. KRAUS, Ph. D.
Professor of Chemistry
Clark University

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THE FUTURE OF SCIENCE IN AMERICA

Charles A. Kraus, Ph. D.
Clark University

It is impossible to discuss any subject of general interest at this time without referring to the war sooner or later. There is scarcely any phase of activity which has not been affected and in many instances the effects will be more or less permanent. Perhaps the one thing most noticeable, aside from the advancing cost of living, is the tremendous awakening of the popular interest in science. Nor is this interest confined merely to the newspapers and the popular journals; it has permeated all classes of society, even responsible government circles. The nations who are now taking account of their stock of resources are devoting much serious consideration to science in all its phases; and fortunate indeed does that nation account itself which finds its supply of scientists anywhere near adequate. Science is playing one of the leading roles in the war itself, and there can be no question but that, when the war is over, science will play a much greater part than ever before in all our lives, both individually and collectively. It is to science that men look in finding substitutes for the workers lost in war, in making good the wastage of material things and in retrieving their fallen fortunes. And to the universities in large measure, falls the task of developing science and disseminating scientific knowledge among those who are to apply it in a practical way for the benefit of mankind.

In the past, Clark University, founded through the foresight and broad minded idealism of Jonas Clark, has been one of the pioneers in American science. On her, among others, falls the stupendous task of preparing the nation so that it may be in a position to attack its problems intelligently. It has seemed worth while, therefore, to discuss here today the future of American science in so far as it may be foreseen, in order that we may be prepared to meet our responsibilities effectively, that we may be prepared to lead rather than to follow in the arduous time that lies before us.

The importance of science to us as a nation, and to mankind as a whole, is now generally recognized. Yet, even among those otherwise well informed, there is much misapprehension as to what constitutes science. Under the abnormal conditions of the present day, perspective has in a large measure been lost; there is a pronounced tendency to magnify the importance of the immediate future in comparison with that of a more distant time.

Most men, when they speak of science today, have in mind technical or applied science. In their minds they see America manufacturing her own dyes, supplying her own nitrates, and what not. This is all very well, but the problem involved in these instances lies not so much in the realm of science as in that of political economy or business finance. Doing what others have done before us does not constitute scientific activity; science is essentially creative. When we are doing what others have not done, when Germany or France or any other country begins to introduce processes which were originated and developed in America, then, and only then, can it be said that we have attained a position in science commensurate with our position as a nation. But before this happy condition can be brought about, not merely technical science but science itself, the knowledge of the laws of nature, must be developed in America to a point in advance of that of other nations.

Much confusion has arisen from a lack of understanding of the true meaning of the terms pure science and technical or applied science. Actually there is no distinction between them save one of degree. Applied science necessarily deals with that phase of science whose results are more or less immediately applicable to the needs of man; pure science is concerned with the discovery of new and fundamental relationships among the complex phenomena of nature in order that man's dominion over nature may be extended. The pure science of today serves as the foundation upon which the great technical developments of tomorrow will be based. It is surprising, indeed, how many men, otherwise well informed, have shown themselves ignorant or unmindful of the fundamental dependence of technical science on its apparently less practical precursor.

In speaking of science, therefore, I shall use the term in its broadest sense, without regard to whether its benefits to mankind will accrue today or tomorrow, within this generation or the next. Before technical science can be developed soundly, it will be necessary to lay the broad foundation of pure science. The pure science of Gilbert, of Galvani, of Volta, of Cavendish and of Faraday, embodied the technical applications of electricity today; the pure science of Carnot, of Clausius and of Gibbs, embodied the technical applications of chemistry of which we hear so much today and of which we shall hear more tomorrow. That branch of pure science which is comprised in what is known as radiactive phenomena today, will surely serve as foundation for a new technical science in the future, the nature of which we cannot now foresee, but whose importance will doubtless surpass our most sanguine expectations.

Using the term science in this sense, and granting that the importance of its development is acknowledged, let us examine the probable future of science in America. The topic is all the more timely, since, in large measure, the development of science abroad has been forcibly arrested, and it may be a long time before normal conditions are restored. In the meantime, we are thrown on our own resources in a much larger measure than heretofore in providing training and inspiration to the rising generation of scientists. It would be a fine thing too, if at this time, when other nations have been forced to stay their development of science, we in America were to take up the task which they have let fall and should extend the field of knowledge beyond its present borders. Then we might repay in some small measure the debt we owe to foreign science for what we have so freely received in the past; for it is indeed true that, while we have accomplished great things in technical science, the results obtained are almost exclusively based on fundamental laws and principles, a knowledge of which has been gained by European men of science through years of self-sacrificing toil.

Naturally, before proceeding to a consideration of the future of science in America, we must attempt to determine its present state and inquire into the part which America has played in its development in the past. It is unfortunately true that, with one or two notable exceptions, America's contribution to science has been almost negligible. Nor is this surprising, since it was not to have been expected that a nation still grappling with nature in its primeval condition should have the energy and the opportunity to devote itself to the development of science. But those times are now well past. We are now situated much as the other nations are and we must be prepared to take our place among them; and our success as a nation will be largely dependent upon our success as scientists.

It is difficult to judge the extent of scientific development and attainment of a people; results are not always tangible, they can not be measured with a yardstick nor weighed in a balance. Perhaps the only simple means of arriving at a conclusion is to examine the literature, both as to amount and content. Unfortunately, it is difficult to compare the content of scientific contributions. We may, however, form an approximate estimate of the extent of scientific activity from the amount of material published. I am aware that this method of comparison is open to objection, but most men who are well informed will agree with me, I believe, that if we compare American and foreign publications page for page, the handicap will not be against American science.

As an example, let us examine American activity in the field of chemistry. I choose this example because it is the field with which I am most familiar. And what is true of chemistry will in a large measure be true of other branches of science.

During 1915, American chemists supported two journals devoted to pure chemistry. Together, these comprised 3,615 pages. During 1913, the last year preceding the war, German chemists supported ten journals comprising in all, 16,260 pages. Perhaps it is a little unfair to take chemistry as a typical example; but it is to be remembered that we have taken no account of the content of the publications. If we were to do this, the discrepancy would become much more alarming than it otherwise appears. Chemistry in America must go far beyond its present bounds before it begins to approach the state of development reached in Germany before the war.

I think that there has been a feeling among chemists during the past ten years that America was making rapid strides in this particular branch of science. Superficially this would appear to be the case. In 1895 the membership of the American Chemical Society was 850, in 1905 it was 2,675 and in 1915 it was in excess of 8,000. This would appear to indicate a rapid and steady expansion of the science of chemistry. Examination, however, shows that the gain has not been in proportion to membership. The expansion of the Society reflects, rather, American industrial development.

In 1895 American chemists supported two journals comprising 1,821 pages, a fair proportion of the contributions dealing with technical subjects. In 1905 American chemists supported three journals comprising 3,712 pages, nearly all the contributions relating to pure science. At the same time a number of American contributions were published abroad. In 1915, as already stated, American contributions comprised 3,615 pages. Thus we see that between 1895 and 1905 scientific activity in chemistry advanced markedly, while from 1905 to 1915 it was practically at a standstill.

That technical chemistry made great advances between 1905 and 1915 is undeniable. This is indicated not only in the rapid growth in membership of the American Chemical Society, but also in the establishment of a new journal devoted exclusively to the interests of applied chemistry. During the past ten years the number of students, both graduate and undergraduate, has increased enormously, with teaching staffs in proportion; yet productiveness in pure chemistry has been practically at a standstill. The causes underlying these conditions form a pertinent subject of inquiry to all those interested in the development of American science.

I would not have it inferred that I decry the development of technical chemistry; quite the contrary, the development of technical chemistry is fundamentally necessary and anything which makes for its healthy growth should be encouraged. It is an open question, however, whether the diversion of a considerable proportion of the academic staffs in our educational institutions from the pursuit of investigations in pure chemistry to activity in applied chemistry constitutes a sound development. I shall revert to this matter presently.

It appears that the development of chemistry as a science has been in a measure arrested. In spite of largely increased staffs in our university departments of chemistry, neither the amount nor the quality of the scientific product has been greatly increased during the past ten years. Two immediate causes are responsible for this condition: first, a falling off of the average ability of those going into academic work; second, a depreciation of academic ideals.

The unprecedented growth of technical chemistry in this country has opened great opportunities for advancement to well trained chemists. There has been an ever increasing demand for men of the highest attainments. Men who, twenty-five years ago, could have satisfied their craving for research only in choosing an academic career, now find a ready opening for their abilities in technical research with a prospect of attractive financial reward. It is an open secret among those familiar with conditions in our larger institutions, that it is becoming increasingly difficult to retain the best men as instructors and assistants. All too often it is the mediocre student or one who lacks initiative, who remains behind as instructor or assistant and who is ultimately advanced to more responsible positions. And this process of selection does not stop with the student who has just taken a graduate or undergraduate degree. For a period of ten years, at least, it continues, some of the most promising men being thus detached from pure science to enter technical activities in one form or another. Anyone who has been in one of our larger universities or technical schools will have no difficulty in recalling examples. It is to be expected that under these conditions science will advance but slowly if at all; for, if our activities do not carry us nearer the condition of science as developed abroad, we shall yet be retrogressing in spite of all our apparent industry.

Whether technical science will be very much the gainer through its successful competition with the academic profession is open to grave doubt. The advance of technical science depends on an adequate supply of well trained men, well trained in the most fundamental principles of science. And such training can be obtained only from teachers of the highest qualifications, from men who see science not only as it is today, but who have some inkling of what is to come. After all, we must educate the student not alone with a view to his immediate necessities, but also with a view to those which will arise at a much later time.

I come now to the second factor which has contributed and is still contributing to our scientific backwardness. I speak of the depreciation of ideals among those teaching science in our colleges, universities and technical schools. This cause is much more insidious than the first. It has crept in little by little and not infrequently has masqueraded under philanthropic guise. The scientist, to be worthy of the name, must be possessed of an insatiable desire to extend knowledge in its most fundamental aspects. He must not count the years of preparation required to actually master his subject, nor the labor necessary to transmute a crude idea into a well polished, finished scientific product. He must never be satisfied with mediocrity, and must ever strive to increase his scope in order that he may produce results of more fundamental importance. With the increasing development of technical science has come increased temptation to leave the tasks of pure science, often laborious and exacting, to turn to minor technical investigations which are less exacting in time and effort and more certain of reward. Under the guise of coöperation with the industries, many a promising man has been led to give up his pursuit of pure science to do the tasks of technical chemistry, tasks, quite often, which technical chemists find too unimportant to carry out themselves. Coöperation between the universities and the industries is most desirable, but in the main, the universities will carry out their task, in providing the industries with an adequate supply of men who possess a broad training and whose ambitions are not entirely focussed on merely increasing their salaries. On the part of the industries, coöperation consists in making it possible for those in academic positions to carry on their work to best advantage, that they may be freed from unnecessary uncertainties and interruptions. The diversion of large portions of the academic staffs from the pursuit of the fundamental problems of pure science to dabbling in the minor details of technical science adds little of direct value to the industries and so lowers the tone of scientific scholarship that technical science as well as pure science must inevitably suffer in the long run. I firmly believe that technical science in America is well able to take care of itself, provided it is able to obtain well trained men from the universities and technical schools. On the other hand, pure science stands in grave danger of never being developed at all.

I should like to quote a few words from an address by Dr. Whitney, himself director of one of the most successful technical research laboratories in America, I quote: "The part of research I am most interested in promoting is what we may call the unpaid kind, not because it is the cheapest but because it is the most valuable. It is most neglected, most poorly understood, most in need of appreciative support in America."

"The separate industries do not need encouragement in research nearly so much as the nation needs it. The industries can be depended on to estimate its value to them for they take inventories. But a country which keeps no books seems to have to depend on instinct and environment for its most valuable research work."

Mr. J. J. Carty, in his presidential address before the American Institute of Electrical Engineers, expresses himself as follows:

"The practical benefits which may be immediately and directly traced to industrial research, when properly conducted, are so great that when their importance is more generally recognized industrial research will not lack the most generous encouragement and support. Indeed, unless industrial research abundantly supports itself it will have failed of its purpose."

"But who is to support the researches of the pure scientist, and who is to furnish him with encouragement and assistance to pursue his self-sacrificing and arduous quest for that truth which is certain as time goes on to bring in its train so many blessings to mankind? Who is to furnish the laboratories, the funds for apparatus and for traveling and foreign study?"

These men whom I have quoted are men who have had years of successful experience in industrial research. If their conclusions are correct, and I believe they are, it is not so much a question of how the universities are to assist the industries in encouraging technical research as of how the industries shall assist the universities in encouraging research in pure science.

When a larger number of men, both within and without industrial science, take the broad view of these gentlemen whom I have quoted, the problems of technical science as well as of pure science will be well on the way to successful solution. Then, too, we shall no longer hear the view, now so often expressed, that if the university professor of science would deign to spend the time which he now devotes to pure scientific research, in investigating some of the minor technical problems he might add materially to his income. As long as such advice is current and as long as university professors take such advice, so long will science in America remain below a productive level.

I have now discussed some of the conditions surrounding scientific positions in America and their influence on productive scholarship. It is almost self-evident that, at the root, American scholarship suffers from a lack of adequate remuneration. It is unnecessary for me to go into details, these have been published where they are accessible to anyone who is interested. However, it will be worth while to trace out in the case of chemical science how this economic force acts. What I have to say about chemistry is, in a measure, applicable to the whole academic profession, but chemistry suffers more than the others because competition for able men between the institutions and the industries is exceedingly keen. The movement has been clearly apparent for more than ten years. The war has aggravated conditions and from anything that can be seen now, it will be a long time before these conditions are even measurably relieved.

The financial returns for academic activity are scarcely comparable with those of the professions such as law, medicine, engineering, etc., and in most cases a longer period of training is required. The financial returns, moreover, bear little relation to the ability or activity of the individual. The services of the most successful chemist in the country for an academic position can be obtained for not more than twice the salary of a mediocre one, and even positions of this kind are very few. However successful the holder of a professorship may be, he cannot hope to add materially to his income through any activity in his capacity as teacher or investigator. The difference between mediocrity and unqualified excellence is so small that an academic position holds forth little incentive to young men who have both ability and initiative. I venture to say that the success of Germany in scientific lines is in no small measure due to the much larger salaries to which her most able men in academic life may aspire.

Another serious factor lies in the conditions under which advancement follows. The average man succeeds to a full professorship, with approximately his maximum salary at the age of thirty-five. Up to this time, the income in an academic position is about the same as in the professional field, although probably smaller. But while the professional man's income is just beginning to advance from this time on, that of his academic brother remains stationary, while expenses are just beginning to mount.

These conditions have their inevitable consequences. The undergraduate and graduate student is fairly well informed on matters of this kind. He is aware of the fact that, no matter how successful he may be in academic work, the most he can hope for is a living wage and he takes a chance at not getting that. Can you blame the best students for not going into pure science under these conditions, when they can go into technical research equally well? And can you wonder that the professional man looks upon the university professor as impractical. He must, indeed, be impractical in the highest degree if he is to choose academic work as a career.

Suppose, however, that a student had allowed his interest in science to get the better of his business judgment. What is the result, in nine cases out of ten? (I am naturally assuming that the man in question has genuine ability). He applies himself to his task with energy and zeal. He teaches his classes and finds time for research and further study. His efforts are recognized and he is advanced. Just about the time when he has mastered his subject, both as to theory and technique, he is promoted to a full professorship and all hope of further advancement ceases. With rising expenses at the age of thirty-five what can he do? Obviously he must increase his income by means of work lying outside his proper field. One of the most common means is that of writing textbooks, or even translating them—and not infrequently the latter course shows the better judgment. If you will take the time to examine the situation carefully, you will find that, in America, productive scholarship either ceases or is greatly curtailed between the ages of thirty-five and forty, when activity should be greatest. Very few American men of science continue productive scholarship beyond the age of forty-five. This is the reason why we have hundreds of textbooks all dealing with the same elementary subject matter and scarcely a single scientific treatise. The bookshelves of our libraries are packed with treatises by English, French, Dutch, and German writers while the works of American writers are found catalogued under "Textbooks for High Schools and Colleges." American writers have not time to write treatises, which are unremunerative, they must devote themselves to subjects in which the classes are large. Thus in American universities young men sell their abilities for a mess of pottage, and we wonder why American scholarship is unproductive.

In the sciences, and particularly in chemistry, conditions are even more serious than in other academic departments, for the door is always open to the technical field, and not infrequently the step into this field brings applause as well as financial reward. It can all be carried out under the high guise of coöperation between the university and the industries. More often, however, matters do not progress so far. The professor merely does "outside work," not infrequently analytical, which is also the worst paid, much after the manner of the wife of the ne'er do well, who takes in washing to make a living for the family. Some few of the more enterprising enter the technical field independently and devote their time to developing inventions or other matters that promise financial reward. I do not say that a chemist in an academic position should not turn his attention to technical problems if his inclinations and abilities lie in that direction, but I do say that when this condition becomes practically obligatory, the ideals of scientific scholarship will depart from our universities.

Finally, a considerable number of chemists who have established their reputations and have demonstrated their ability in productive research, are in demand for technical research positions. Particularly since the outbreak of the war, numbers of chemists have left their chairs to take up technical research work. While this tendency has been accentuated by war conditions, the movement was well under way some years before the war began and it gives evidence of continuing after the war is over.

What then will be the consequences? What influence will these conditions have on the development of chemistry, in fact, on the development of science generally in America? Unquestionably, unless pure scientific work can be made to appear possible even if not attractive from a financial point of view, pure science will fall to a level relatively lower than that which it now occupies. The qualifications of our teachers of science will deteriorate, and ideals of research, which for a time were rapidly growing, will degenerate and we, a great nation in numbers and natural resources, will find ourselves outdistanced by nations who are less fortunately situated but who handle their problems in a more intelligent manner. Nor should the industries lull themselves to sleep with the thought that, since they command the best scientific talent of the country, they have nothing to fear. A fountain rises no higher than its source, and our men will take away with them from the universities ideals which are on a par with those of their professors.

The situation is fraught with the gravest consequences for the industries. For, while industrial research has obtained an uncommonly firm foothold in America during the past fifteen years, there are required thousands of men imbued with the highest ideals and trained according to the best standards.

Where shall these men obtain their ideals and their training? Not in Europe, for years after the war. Where then? From contact with instructors and professors of second or third rate intellectual ability?

Unless pure science is brought up to and maintained at a high average level, technical science along with pure science will suffer, and in the future as in the past America will continue to trail in the wake of foreign scientific progress.

The situation is indeed grave, the more so, since it is but little understood and our more or less artificial industrial expansion consequent on war conditions is mistaken for real scientific progress. A lasting development of science in America will come when our academic scientific positions are clothed not alone with the dignity of social position but likewise with the dignity of adequate remunerative reward. Then, and only then will science be able to attract men of the highest intellectual attainments, men who possess, among other things, that most essential prerequisite to creative work, namely, originality. The present barrenness of science in America is due not so much to a lack of opportunity and material facilities as to a lack of aptitude for research among our scientists. The only practical means of raising the intellectual standard of the academic profession, indeed of our universities as a whole, lies in increasing the desirability of our academic positions, in making the competition for such positions so keen that all but the most able and original will be weeded out. And this process must not stop with the selection of instructors and assistants from among graduate and undergraduate students, it must continue until the holder of an academic position has reached the point of his highest efficiency. Scientific merit must be assured of recognition and the sooner recognition follows performance and the more nearly it corresponds to the merits of the performance, the larger will be the number aspiring to recognition and the greater will be the production of scientific work.

Out publicists who deal with scientific educational matters must wake up and give these questions candid discussion, even though they may occasionally offend our vanity. The public at large as well as those more immediately interested in educational matters must come to a clear understanding of what the situation really is before conditions can be materially improved.

Whether or not you accept my conclusions, if what I have said will lead you to reflect on the causes underlying the present state of unproductiveness of American science, and on the best means of improving this condition, your time and mine will not have been spent altogether vainly on this occasion.

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